



Checkmate Technology, Inc.

MultiRam™ //e

The Memory Card with a Future

Users Manual

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TABLE OF CONTENTS

Preface - How To Use This Manual	v
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GETTING STARTED

Chapter 1 - Introduction	1.1
Features	1.1
Standard Features	1.2
Optional Features	1.3
Hardware Requirements	1.3
Chapter 2 - Installation	2.1
Unpacking The MultiRam //e	2.1
Card Care	2.1
Physical Description	2.2
Ram Banks	2.2
Jumper Block	2.2
LEDs	2.2
CPU Port	2.4
MultiRam RGB Connector	2.4
Installing Additional Memory	2.4
Original RAM	2.5
User Installed RAM	2.5
Dealer Installed RAM	2.8
Factory Installed RAM	2.8
Installing The MultiRam //e Card	2.8
Preparation	2.8
Inserting The Card	2.9
Chapter 3 - Testing & Troubleshooting	3.1
Test Procedures	3.1
Test Display	3.1
Test Selection	3.2
Running A Test	3.2
Test Results	3.6
Non-RAM Problems	3.6

USING THE MULTIRAM //E CARD

**Chapter 4 + 5 Have Been Enlarged And Moved To The
MultiRam Software Manual.**

Chapter 6 - Hardware and Software Compatibility	6.1
Hardware	6.1
Disk Disks	6.1
Co-Processor Cards	6.2
Non-Interruptable Power Supplies	6.2
Software	6.3

PROGRAMMING THE MULTIRAM //E CARD

Chapter 7 - 80-Column Displays	7.1
Keyboard Control	7.1
Activating 80-Column Displays	7.1
Switching Between 40- and 80-Columns	7.1
Deactivating 80-Column Displays	7.2
Editing Commands	7.2
Uppercase Restrict Mode	7.3
Control Character Display	7.3
Program Control	7.3
Card Activation/Deactivation	7.3
Cursor Moving	7.4
Screen Clearing	7.5
Display Features	7.5
Chapter 8 - Programming Auxiliary Memory	8.1
General Information	8.1
Bank Switching	8.2
Auxmove and Xfer	8.4
Chapter 9 - Auxiliary Memory Management	9.1
Selecting Auxiliary Memory Banks	9.1
Programming Guidelines	9.2
Softswitch Selection	9.2
Initializing The Card	9.2
Identifying MultiRam //e Memory	9.3
Memory Bank Mapping	9.4
Memory Transfers	9.4
80-Column Addressing	9.5
Reset Key Trapping	9.5
Interrupt Handling	9.5

MULTIRAM //E SERVICE GUIDE

Chapter 10 - The Warranty	10.1
Second Hand Ownership	10.1
Extending The Warranty	10.2
Chapter 11 - Service Policies	11.1
How To Get Help	11.1
Telephone Help	11.1
Telephone Policy	11.1
How To Return A Card	11.2
Returning Your Repaired Card	11.2
Ram Installation & Replacement Policy	11.3
Replacing Damaged Diskettes	11.3
Software Updates	11.3
Newsletters	11.4
Independent Software Developers	11.4
Suggestions	11.4

PREFACE

Preface

HOW TO USE THIS MANUAL

This manual is divided into four parts.

Part 1

GETTING STARTED, should be read first by everyone. Chapter 1 summarizes MultiRam //e's features and minimum hardware requirements. Chapter 2 gives step-by-step instructions for installing MultiRam //e and adding memory to the card. Chapter 2 is required reading for those of you who intend to install your own RAM. Chapter 3 covers testing and troubleshooting procedures.

Part 2

USING THE MULTIRAM //E CARD, shows how to use the software included with your MultiRam //e Card. Chapter 4 explains how to use MultiRam //e's large memory with AppleWorks. Chapter 5 shows how to use MultiRam //e as a fast RAM disk drive for DOS 3.3 and ProDOS. Chapter 6 covers software and hardware compatibility questions.

Part 3

PROGRAMMING THE MULTIRAM //E CARD, should be read if you intend to develop software using MultiRam //e's memory. If you don't intend to program MultiRam //e yourself, you may skip this section. Chapter 7 explains how to program 80-column screen displays. Chapter 8 details programming techniques required to use the standard auxiliary memory bank. Chapter 9 shows how to use all of MultiRam //e's 64K auxiliary memory banks.

Part 4

THE MULTIRAM //E SERVICE GUIDE, should be read by everyone. Chapter 10 describes the MultiRam //e warranty. Chapter 11 tells how you can get service if you have a problem and explains RAM replacement and software update policies.

This manual assumes you know how to operate your Apple //e. If you are a new Apple //e owner or if any terms or procedures in this manual are unfamiliar to you, please refer to your Apple //e owner's manual for help.

Part 1

GETTING STARTED

Getting Started describes the MultiRam
//e Card's features and instructs you in
installing and testing the card.

Chapter 1

INTRODUCTION

The MultiRam //e Card is an expandable extended 80-column memory card for the Apple //e. MultiRam's memory is expandable from 64K to 768K and has a built-in 16 bit processor port. An optional 768K expansion board is available to connect to the MultiRam //e memory card giving a total on-board memory of 1.5 megabytes and RGB video!

MultiRam //e fits into the //e auxiliary slot and functions like a standard Apple extended 80-column card. It is 100% compatible with all programs designed to show the //e 80-column display or double hi-resolution graphics and those programs using an additional 64K of auxiliary memory.

Memory can be easily added to MultiRam //e in either 64K or 256K increments. MultiRam //e is shipped with a minimum of 64K memory installed. With more than 64K installed, MultiRam //e brings greater power and versatility to your Apple. In the near future, several new and powerful business programs from third party software publishers will become available for the MultiRam //e.

The best selling program for the Apple, AppleWorks, can now use all of MultiRam //e's memory, up to 1.5 megabytes. MultiRam //e and its AppleWorks Expansion software eliminate the 55K memory Desktop limit that is normal for AppleWorks with an ordinary 64K memory card. A 768K MultiRam //e card, for example, offers usable AppleWorks Desktop space of 568K. By removing AppleWorks memory limitations, MultiRam //e truly turns AppleWorks into one of the best integrated packages available for any microcomputer. Use the MultiRam //e card, AppleWorks, and a hard disk drive together and the Apple //e becomes a serious business machine capable of the most demanding tasks.

With the RAM drive software included with MultiRam //e, programs can be accessed over twenty times faster than is normal with standard Apple disk drives. With 768K installed, MultiRam can take the place of six ordinary Apple disk drives; twelve if a full 1.5 megabytes is installed. Put your favorite unprotected programs onto a RAM drive and discover how easy it can be to quickly move between application programs.

FEATURES

MultiRam //e offers more standard and optional features than any other extended memory card for the Apple //e. MultiRam //e is also easily expandable so that you can purchase the card with as little memory as you need today and grow into more memory as your needs and budget allow. MultiRam //e's flexibility insures your Apple //e of a long, productive life.

Standard Features

The MultiRam //e package comes with a large number of standard features:

- Adds 64K to 768K (3/4 megabyte) to the Apple //e
- Uses standard 150 nanosecond 64K or 256K RAM chips (you can even add the 64K chips from your old extended 64K card to MultiRam //e)
- Easily user upgradeable at any time with nine memory configurations possible:

64K	256K	512K
128K	320K	576K
192K	384K	768K

- Has four LED 64K bank display indicators for programming convenience and operational verification
- Software included to:
 - Configure AppleWorks to use all of MultiRam //e's memory
 - Use MultiRam //e as a ProDOS RAM disk emulator
 - Use MultiRam //e as a DOS 3.3 RAM disk emulator
 - Test MultiRam //e memory for defective RAM
- Expansion connector to allow an optional MultiRam RGB memory expansion board to be added with up to 768K of additional memory
- 16 bit CPU port to allow direct linear memory addressing by 16 bit microprocessors and an optional 65C816 processor board
- 100% //e software compatible
- 80-column standard video
- Supports double hi-resolution graphics
- Jumper allows card to work in older "A" Apple //e motherboards
- Compatible with both the enhanced and non-enhanced Apple //e
- Software updates available
- Exclusive memory management addressing modifiable through a factory PAL update
- Full 5 year warranty on the card and all Checkmate Technology supplied components

Optional Features

MultiRam //e offers a number of options for those who demand more out of their Apple //e:

- 64K or 256K RAM kits to expand the memory of MultiRam //e with tested, 5 year warranted RAM chips

- The MultiRam RGB Card:

- Adds 3/4 Meg expansion capacity to the MultiRam //e for a total of 1.5 megabytes
- Produces RGB video signals with 16 levels of intensity in color or monochrome displays
- Pascal RAM disk emulator
- CP/M RAM disk emulator
- 16 bit 65816 processor card that can directly address all MultiRam //e memory without bank switching to give the Apple //e super-micro capabilities

H A R D W A R E R E Q U I R E M E N T S

The minimum equipment requirements to use MultiRam //e are:

- An Apple //e computer (enhanced or unenhanced). MultiRam //e will not work in an Apple //c or in the Apple II, II+ or Apple II+ compatible computers.
- A disk drive to use MultiRam //e software.
- A monitor suitable for 80 column display.

Chapter 2

I N S T A L L A T I O N

This chapter contains all the information you will need to install your MultiRam //e card. Package contents, card care instructions, a physical description, and instructions for RAM additions and card installation are covered.

U N P A C K I N G T H E M U L T I R A M / / E

Check the contents of your MultiRam //e package to be sure you have the following:

- This owner's manual
- MultiRam //e Card
- A floppy disk, containing:
 - Side 1 - AppleWorks Memory Expansion program
 - Side 2 - Utilities which include DOS 3.3 and ProDOS
RAM disk drive emulator programs, and a RAM
test program
- A warranty card

Contact your dealer or Checkmate Technology if anything is missing.

You should fill out and return your warranty registration card as soon as possible. Only registered owners will be notified of updates to the software packaged with the MultiRam //e Card.

C A R D C A R E

Always ground yourself before handling or touching the MultiRam //e Card. Touch any metal object to discharge static electricity from your body. Static electricity, which can build up on your body, can damage RAM chips. The 256K RAM chips, which may be installed on your card, are more sensitive to damage by static electricity than 64K chips.

Handle the MultiRam //e Card carefully, by the edges. Do not flex your card when handling it as this can lead to weakening of connections.

Avoid touching the gold-plated fingers at the bottom of the card. These contacts must be clean as they connect MultiRam //e to the Apple. Clean these contacts if needed with isopropyl alcohol.

Never insert your card into or remove it from the computer while the Apple's power is on. You can damage the card, the Apple, and other cards in the Apple's slots. You will void your MultiRam //e warranty.

When installing added RAM, as discussed later, try to minimize the number of times RAM is inserted into and removed from the MultiRam //e's sockets. Even our quality sockets will be degraded by excessive insertion and removal of RAM I.C.'s.

PHYSICAL DESCRIPTION

After unpacking the MultiRam //e card, carefully set it down flat on a clean, dry surface, with the sockets and other component facing up. Place the card so that the gold-fingered connector at the bottom of the card is facing toward you. Compare your card with Figure 2.1 and locate the following components.

Ram Banks

There are three banks of sockets on the card into which RAM chips can be inserted: Bank A, Bank B, and Bank C.

Bank A is the most important of the three banks. Either 64K or 256K chips must be present in this bank for 80-column video to operate and for all programs requiring auxiliary memory to work. Bank A is located across the top of the left half of the card. Bank A consists of eight sockets, labelled A1 to A8. Bank A is labeled "BANK A" and its sockets are marked by a line around them.

Bank B is located in the middle of the card and is formed in a "T" pattern outlined with a white line. Bank B sockets are labeled B1 to B8.

Bank C is located at the right end of the card. Marked by a white line around them, sockets C1 to C5 form a vertical row at the right most end while the lower three chips of the vertical row immediately to the left complete Bank C with sockets C6 to C8.

Adding to or changing the RAM chips of these three banks is discussed later.

Jumper Block

Near the bottom edge of the card, about 1/3 of the length of the card from the left end (below the cheas-piece trademark of Checkmate Technology) is a small plastic block mounted on two pins, labelled "J1". This jumper block must be removed if you have an early model of the Apple //e (Revision A motherboard) in order for MultiRam //e to operate properly. Owners of more recent models should leave the block on the card. How to know if you need to remove the block is covered later in this chapter.

LEDs

At the extreme left end of the MultiRam is a vertical row of four small, red Light Emitting Diodes (LED). These are labelled 1, 2, 4, and 8. The LEDs provide a visual indication of the exact 64K memory bank currently read from or written to. Provided primarily for programmers' use, the LEDs let anyone

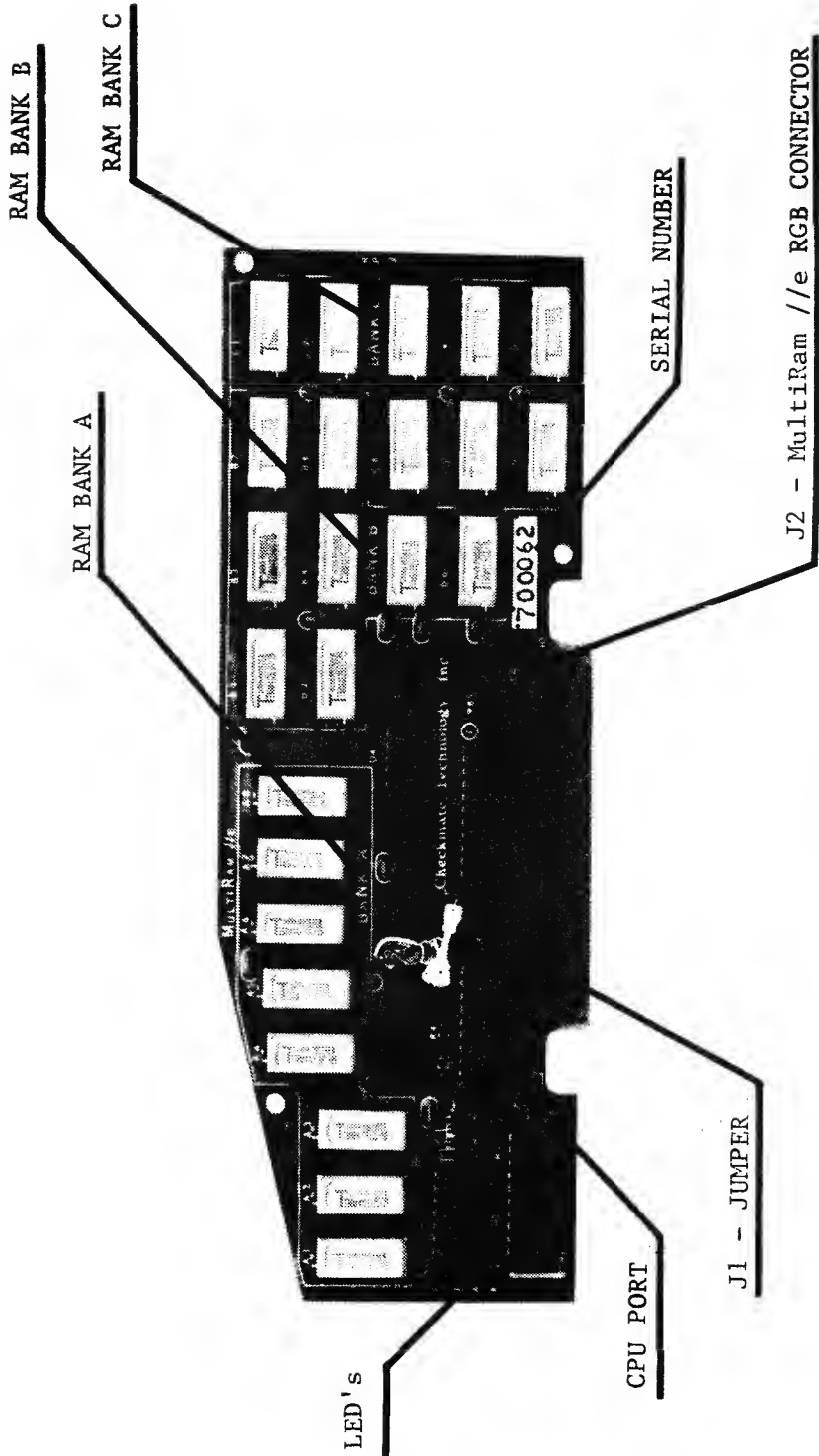


FIGURE 2.1

quickly determine if a program is using the card's memory beyond the ordinary first 64K auxiliary bank.

CPU Port

Near the left bottom edge of the card, just to the left of the Jumper Block, is a socket labelled CPU PORT. This is an expansion socket into which may be inserted a cable connected to an optional 16-bit processor card. A 16-bit processor can directly and linearly address all of MultiRam //e's memory.

The exclusive CPU Port opens your Apple to the world of more powerful 16 bit software. MultiRam //e, unlike all other extended 80-column cards, will not become obsolete as 16 bit microprocessors become the standard. The CPU Port can be used by 65C816, 68000, and 8086 processors. A 65C816 processor board is being developed by Checkmate Technology for use with MultiRam //e. Processor boards from third party manufacturers will also be able to tap MultiRam //e's large memory.

MultiRam RGB Connector

Directly above the gold-fingered motherboard connector is a memory expansion connector, marked "J2".

A companion board to the MultiRam //e, the MultiRam RGB Card, can be attached at the expansion connector. MultiRam RGB offers RGB video output and 768K memory capacity. The two cards combined together total 1.5 Megabytes memory capacity! Designed to work together when installed in the Apple //e, the two cards will not interfere with any other slot, thus allowing any card to be used in slot 1.

INSTALLING ADDITIONAL MEMORY

Your MultiRam //e Card has three banks of eight sockets labeled Bank A, Bank B and Bank C. Either a 64K or a 256K dynamic RAM set of eight chips may be installed in each bank. The three banks are clearly defined on the card (see Figure 2.1).

With the three banks, there are nine memory combinations possible as Table 2.1 shows.

Table 2.1 Ram Banks And Size Combinations

	1	2	3	4	5	6	7	8	9
BANK A	64K	64K	64K	256K	256K	256K	256K	256K	256K
BANK B		64K	64K		64K	64K	256K	256K	256K
BANK C			64K			64K		64K	256K
Total	64K	128K	192K	256K	320K	384K	312K	576K	768K

If your card only has 64K of RAM installed, you may wish to add RAM to it at a future date to increase its memory. RAM may be installed by you, the dealer, or Checkmate Technology.

Original Ram

Each MultiRam //e card is shipped with a minimum of 64K in Bank A, which means Bank A will have a full set of eight RAM chips. Bank A must be populated with at least 64K chips in order to provide 80-column video and to work with those programs requiring a 128K Apple //e configuration. Your MultiRam //e card may contain RAM in other banks or 256K RAM in Bank A as your dealer may have ordered the card with more memory or may have installed his own RAM chips.

Look on the back of your card, at the area near the hole at the top left edge of the card, and you should see a three-digit code. This code tells how the card was configured when it left the factory.

The first digit represents Bank A, the second Bank B, the third Bank C. A "0" means the bank was empty when the card was shipped, a "1" means a set of 64K chips was installed, and a "2" means a set of 256K chips was present. For example, the code "1 0 0" indicates that the only bank with RAM installed was Bank A, and it was a 64K set; "2 1 0" indicates that Bank A left the factory with a set of 256K RAM installed, Bank B contained 64K and Bank C was empty.

If the card, as purchased, is not configured as indicated by the code, additional RAM has been added or replaced on the card.

It is normal for dealers to install their own RAM in order to limit the different RAM sizes they stock. Dealer installed RAM does not void the card's warranty. Checkmate Technology guarantees for five years only those RAM chips that are installed and tested at the factory or RAM chips sold in kits by Checkmate Technology, Inc., and kits available at your local dealer.

We cannot guarantee non-Checkmate Technology RAM chips which are added by you or a dealer. Refer to Chapter 10, which explains the terms of Checkmate Technology's five-year warranty on the card and its components.

User Installed Ram

To install your own RAM, you will need to purchase one or more sets of eight 64K or 256K dynamic RAM chips. RAM on MultiRam //e must always be installed in sets of eight in order to generate 64K or 256K of memory.

Chips installed in a bank of sockets must always be all the same type -- 64K or 256K. Although mixing chips will not harm the RAM or the card, you will lose the use of 192K of a bank of 256K chips if one 64K chip is accidentally installed into the bank. Similarly, only 64K of a 256K chip installed into a bank of 64K chips is usable.

Ask for a speed rating of 150 nanoseconds on the dynamic RAM you purchase, although 200 nanosecond 64K or 256K DRAM chips will work in the computer. You should try to purchase a set of eight RAMs that are the same speed and made by the same manufacturer to minimize potential compatibility problems.

If you are unfamiliar with purchasing RAM, ask your dealer for Checkmate Technology's RAM Kit. The RAM in each Kit is guaranteed to work with MultiRam //e when correctly installed, and are warranted for five years by Checkmate Technology. If you return a card to Checkmate Technology with defective RAM you inserted into the card (other than from a Checkmate Technology RAM kit), you will be charged a service fee plus RAM replacement cost to repair the card. Refer to Chapter 11 for more information.

Ram Removal

If you own a 64K extended memory card and are replacing it with MultiRam //e, you may wish to remove the set of 64K RAM chips from the old card and add them to the MultiRam //e card.

To remove chips from any card, you should use an "IC-puller" (an inexpensive tool designed for removing integrated circuits, and widely available at electronics supply stores). Lacking an IC-puller, an ordinary flatware spoon can be inserted between the chip and the socket and the bowl portion can be used to rock each end of the chip loose.

Carefully remove each chip from its socket by gently prying the ends of the chip upward, a little at one end and then the other, being careful not to damage or bend the pins. Be sure you are prying only the chip and not the entire socket; very little pressure is necessary.

Installation Order

If you are installing one or more banks of 256K RAM, we recommend you follow the placement order shown in Table 2.1: first install a set of 256K RAM in Bank A, second in Bank B, last in Bank C. All 64K RAM should be installed to the right of 256K banks. If two banks are left empty, they should be Banks B and C; if one is empty, it should be Bank C. In other words, start installing RAM from the left, and use sets of 256K RAM before 64K.

Although the only essential RAM placement requirement for existing software is that Bank A always must be populated with either 64K or 256K chips for 80-column displays and programs requiring 128K to work, the placement of RAM suggested in the preceding paragraph should insure that future software developed for MultiRam //e by third party software writers will work with the card. All software developed by Checkmate Technology does not and will not require 256K RAM to be placed in any specific location.

Installation Procedure

To install a set of RAM chips, lay MultiRam //e down flat on a table, with the socket side up, and the bottom (with the row of gold fingers) towards you. The eight sockets of Bank A will be at the left end (see Figure 2.1); there should already be a set of RAM installed in that bank. If Bank B is empty, the next set of RAM should be plugged into those sockets; or if two sets are already installed, you may plug your RAM into Bank C. Or if Bank A contains 64K RAM, and you are adding 256K chips, you should remove the chips from Bank A and substitute the 256K chips.

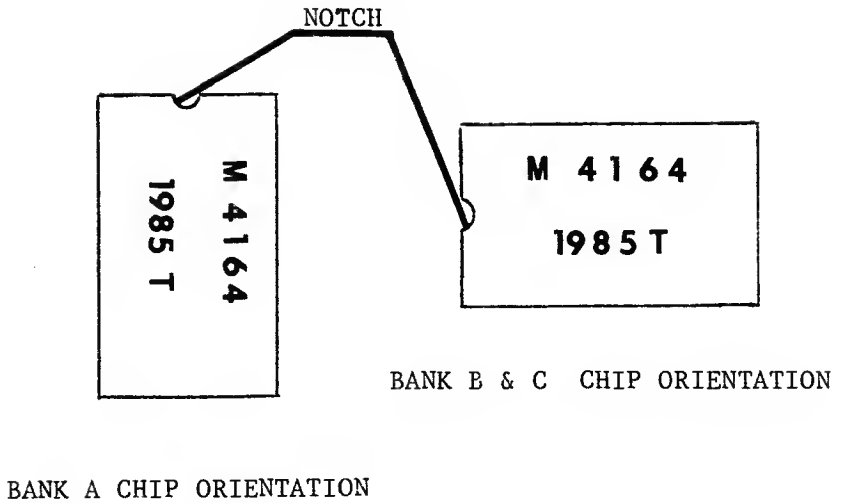


FIGURE 2.2

LAST LETTER IN SERIAL NUMBER
DESIGNATES 'A', 'B', OR 'C' MOTHERBOARD

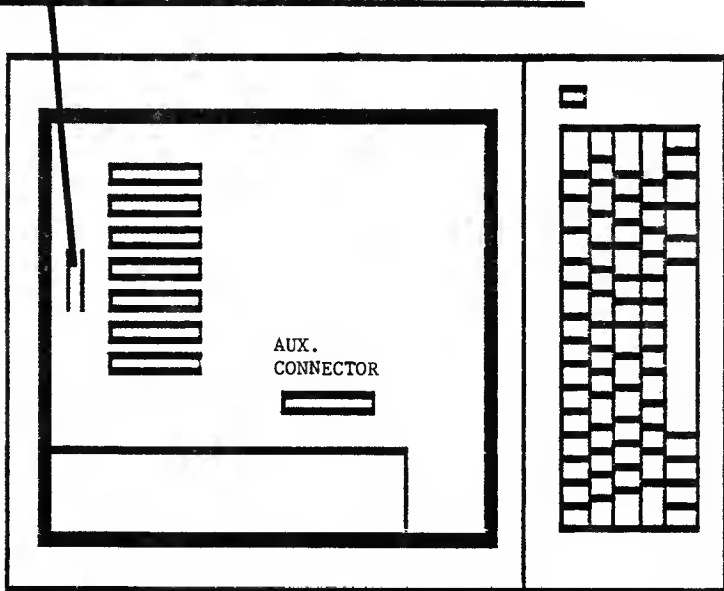


FIGURE 2.3

Most RAM chips have a notch or dot at one end to designate pin one. The chip notch should match the notch on the chip drawing under the socket. Bank "A" sockets show the notch at the top, Banks "B" and "C" sockets are to the left. For additional help refer to figure 2.2.

WARNING! IF A RAM CHIP IS INSTALLED BACKWARDS, IT MAY BE DESTROYED WHEN POWER IS TURNED ON. THE MULTIRAM //E CARD WILL NOT BE DAMAGED.

Carefully line up both rows of pins with the holes in a socket and press the chip into the socket, seating it firmly. Check that none of the pins are bent out or bent under the chip. Repeat the process with each chip until the bank is filled.

When you have finished installing any additional memory, you are ready to install the MultiRam //e card with the power TURNED OFF in your computer.

If you have any doubts about removing or installing the chips, have a service-person do it for you.

D e a l e r I n s t a l l e d R A M

You may have your dealer install RAM at the time you purchase your card or at a later date. Be certain that the installed RAM passes the test program supplied with the MultiRam //e Card (described in Chapter 3).

Refer to Chapter 11 if your card containing dealer installed RAM is in need of service.

F a c t o r y I n a t a l l e d R A M

You may return your card to Checkmate Technology to have additional RAM installed on the card. All factory RAM is thoroughly tested on the card at the factory and is warranted for five years. Refer to Chapter 11 for more information.

I N S T A L L I N G T H E M U L T I R A M // E C A R D

The MultiRam //e Card must first be configured for the type of //e it is to be used in.

P r e p a r a t i o n

The MultiRam comes ready to use on current Apple //e enhanced motherboards.

Current Apple //e computers are "Enhanced," with a revision of components on the motherboard so the //e more closely resembles the //c. These machines can be recognized by the word "Enhanced" that appears on the power indicator light on the lower left of the keyboard, and also by a large letter "E" on the left rear of the motherboard. Skip to the next section, "Inserting the Card," if your Apple is enhanced.

For owners of earlier, non-enhanced //e computers, there are three versions of the motherboard — Revisions A, B, and C. For the Revision A motherboards, the earliest Apple //e, a simple modification is necessary to prepare the MultiRam //e.

To see if you have a Revision A motherboard, remove the cover from your Apple and look at the back edge of the motherboard, just behind the row of seven peripheral slots, near the middle. You should see the words "APPLE COMPUTER" and below them the serial number (see Figure 2.3). The last character is a letter — A, B, or C. If the letter is an "A", yours is the Rev. A motherboard. (Note: if you have an enhanced //e you have read too far; the enhanced model starts the motherboard series with Rev. A; this is not the same Rev. A board as in the non-enhanced //e. No modification is necessary if you have an "Enhanced" //e.)

If you are installing the MultiRam //e on a Rev. A (non-enhanced) motherboard, refer to Figure 2.1, and locate the Jumper Block, "J1", along the bottom of the card, below the trademark (chess pieces). Remove this block by simply pulling it outward from the card. You might wish to place it back on just one of the exposed pins for storage. If your motherboard is a Rev. B or C, leave the block in place covering the two pins.

Newer versions of the non-enhanced //e motherboard (Rev. B or C) have double high-resolution graphic capabilities, not available on the earlier Rev. A board. Double hi-res graphics are included on the enhanced //e.

I n s e r t i n g T h e C a r d

The MultiRam //e must be inserted into the auxiliary connector slot on the //e motherboard.

Be sure the power to the //e is turned off. It is best to be doubly sure by unplugging the power cord.

YOU SHOULD NEVER INSERT OR REMOVE A PERIPHERAL CARD WITH THE POWER ON, AS IT WILL ALMOST CERTAINLY DAMAGE COMPONENTS ON THE MOTHERBOARD, AS WELL AS THE PERIPHERAL CARD. YOU WILL VOID THE MULTIRAM //E WARRANTY IF THE CARD IS REMOVED OR INSERTED WITH THE POWER ON.

If you have not already removed the cover from the //e, do so now. Next locate the power supply. It is the large metal box sitting on the left side of the motherboard. Before touching a peripheral card or other sensitive component, it is a good idea to ground static electricity by touching, with your fingers, the top of the power supply case.

Now locate the auxiliary connector slot. It is about an inch to the right of the front (toward the keyboard) of the power supply, and is identified by the words "AUX. CONNECTOR" printed on the motherboard alongside it (see Figure 2.3). The MultiRam //e Card is to be installed in that slot.

If there is another 80-column card in the auxiliary slot, remove it before continuing. With the power off, pull up on the card while rocking it back and forth until it pulls free of the slot. If that card is a 64K auxiliary memory card, you may want to remove the RAM chips and install them on the MultiRam //e before proceeding (see "Installing Additional Memory" in this chapter).

Hold the MultiRam //e Card with the sockets and components facing to the right. The front of the card slopes downward from the top and should face toward the keyboard. Due to the design of the card, it cannot be inserted any other way.

Insert the foot of the card, the gold-fingered connector, into the auxiliary connector slot. Use a gentle back-and-forth rocking motion along the length of the card to seat it.

Check the MultiRam card. Be certain it is seated firmly into the slot and is not loose.

Replace the cover of the Apple.

Now turn to Chapter 3 to test your new card for proper functioning.

Chapter 3

TESTING & TROUBLESHOOTING

This chapter covers testing procedures you may use to check the RAM on your MultiRam //e Card.

This chapter should be read by everyone who has just bought and installed the MultiRam //e Card. You should always refer back to this chapter when you add or replace RAM on the card or if a problem develops while using the card.

TEST PROCEDURES

On the back side of the disk supplied with your card, the side marked "Utilities", is a test program that will identify good RAM, bad or missing RAM, and will alert you if a 64K chip has been placed into a bank of 256K RAM or vice-versa.

Before continuing, please make a backup copy of the Utilities side of the disk if you have not already done so. Use The Filer from the ProDOS User's Disk or COPYA from a DOS 3.3 System Master disk to copy Utilities to a blank disk. See your //e manual for detailed disk copying instructions.

Insert a backup copy of the Utilities disk into disk drive 1 and boot the disk. You will see a menu. Choose the MultiRam //e test from the menu.

Test Display

A 40-column screen display known as the "status page" should appear.

You should see twelve 64K auxiliary bank indicators on the left side of the screen numbered from 0 to 11. Since the Apple's 6502 processor cannot address more than 64K of memory at a time, the Apple swaps memory banks into and out of its addressing range in order to use MultiRam //e memory. Therefore, the auxiliary bank indicators show MultiRam //e auxiliary memory as the Apple sees it -- one bank at a time, not 128K or 512K or any amount of memory larger than 64K.

On the right side of the screen the usable memory in RAM Banks A, B, and C is identified and the total usable memory available on the card is shown. Upon boot-up, question marks appear instead of numbers on both sides of the screen as the card has not yet been tested (see Figure 3.1).

The bottom two lines of the screen show the keys that may be used to run testing:

- Pressing the Arrow keys position a flashing, solid cursor in a box to the left of the six applications shown.
- Pressing the Return key runs the application marked by the flashing cursor.
- Pressing the Esc key aborts "full" or "continuous" tests.
- Pressing the Space Bar once pauses "full" or "continuous" tests; pressing it again resumes the tests.

Four tests are shown on the menu: a "quick" test, a "full" test, a "continuous" test, and an "80-column test".

Test Selection

The "quick" test checks a very small percent of the memory in a RAM chip in a short time. The test will run in three seconds. Use this test to quickly find major RAM failures. If RAM is bad in an area other than the few places the test checks, a bad chip may be undetected by this test.

The "full" test exhaustively tests all 64K of each auxiliary bank available on the card. The test runs approximately three seconds per 4K. You should always run the full test after adding or changing RAM on the card or when first installing the card. The "full" test runs the "quick" test and then exhaustively checks all banks found good by the "quick" test. Bad or incomplete banks are not tested as they could not be used by any program.

The "continuous" test runs the full test over and over until you press the Escape key. Use the continuous test if a problem develops with the card after it has been in use for awhile as many problems with RAM show up as intermittent problems. One run of the "full" test might not disclose such a problem whereas its continued running would.

The "80-Column Test" allows a visual check of the part of auxiliary memory dedicated to displaying 80-columns.

If RAM in the text video page is bad or incomplete, you will see the message "NO 80 COLUMN VIDEO AVAILABLE DUE TO INCOMPLETE AUXILIARY MEMORY BANK 0" on the 40 column screen.

If there is no RAM failure, you will see eight repeated printings of the ASCII character set in ascending numeric order on the 80-column screen. The inverse ASCII character set is printed first, followed by the normal set, each set repeated eight times. Check to see if there are any breaks in the character pattern. Any breaks will indicate RAM failure. If a failure is suspected, run the continuous RAM test to locate the bad chip.

Running A Test

Running the "quick", "full", or "continuous" tests shows a high resolution picture of the MultiRam //e Card. Each RAM socket is shown exactly as laid out on the card.

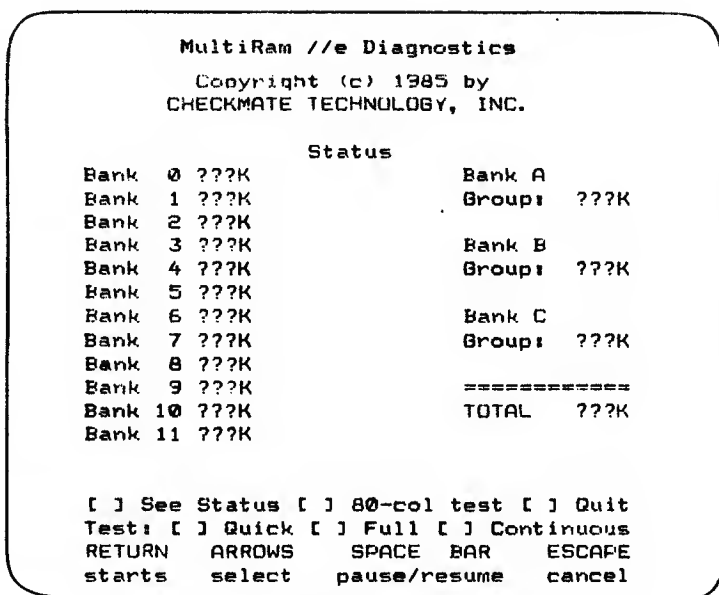


FIGURE 3.1
Status page before testing

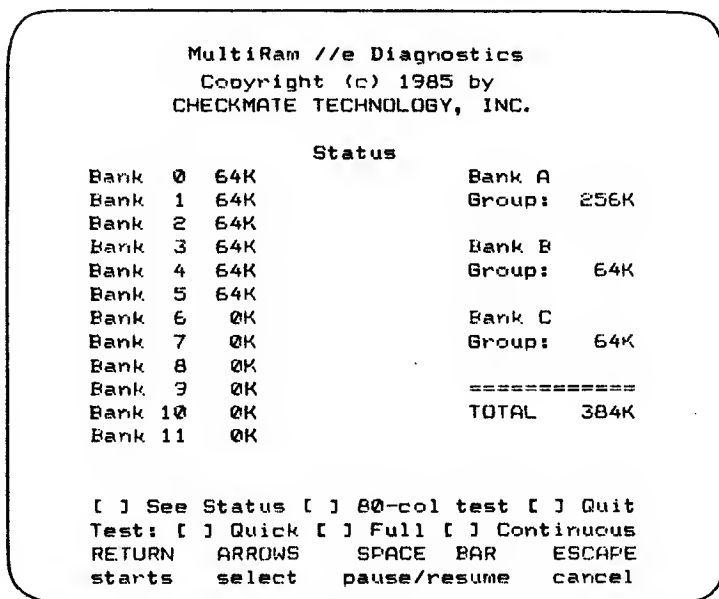


FIGURE 3.2
Status page after testing 384K card

Each socket is divided into four squares. Each socket is shown as four squares because MultiRam //e can contain twelve 64K auxiliary banks in its three RAM banks (Figure 3.3). The Apple, through MultiRam //e circuitry, addresses these twelve 64K banks as follows:

BANK A

0
3
4
5

BANK B

1	6	7	8
---	---	---	---

BANK C

2	9	10	11
---	---	----	----

Running any of these tests, you will see a spinning cursor appear in place of the flashing cursor in the bottom four lines of the screen. The cursor will spin until the test is completed.

You will also see four flashing lights blink off and on on the left side of the picture. These lights correspond to the flashing LEDs on the card and show which of the twelve banks of auxiliary 64K is being currently tested. Add together the numbers that are to the left of the lit LEDs to see which bank is being tested. Auxiliary banks are tested from 11 to 0 in descending order.

At the end of a test, you will see one of three markings appear in each quarter of the sockets:

- A "+" on a black background indicates the RAM in the 64K auxiliary memory segment, whether found on a 64K RAM chip or a 256K RAM chip, tested good.
- An "x" on a white background indicates the RAM in the 64K auxiliary memory segment is probably good but can't be completely tested as another chip in the same group of sockets tested bad, was missing, or was not the same size as the other RAM in the group.
- An empty square indicates bad RAM or missing RAM.

After a test is run, you may select the option "SHOW STATUS" and see a summary of usable memory (Figure 3.2). The twelve banks show 64K for good RAM, OK (zero) if RAM is missing or bad in the bank. A bank having 256K chips, where one or more 256K chips are "partially" defective, can show 64K available in that bank.

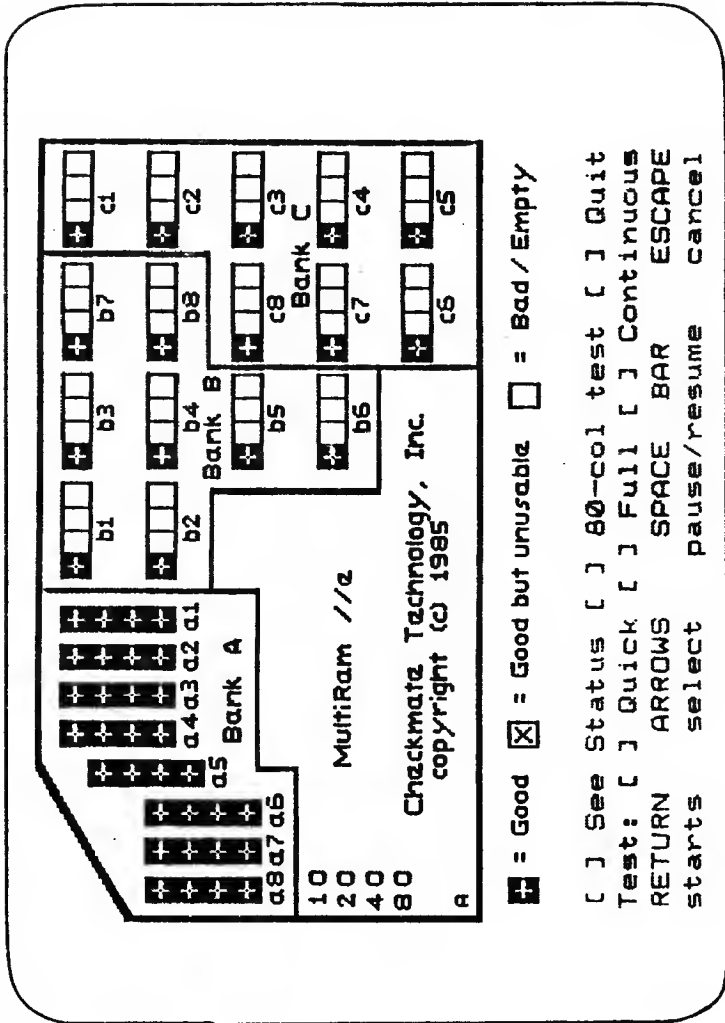


FIGURE 3.3
Successful test of 384K RAM

Test Results

Several reasons may lie behind an appearance of a blank square or a "X" in a square. If these results are shown as the result of your testing, write down the socket number of those chips that test "bad." Turn off the Apple, remove its cover, and remove the MultiRam //e Card from the auxiliary slot for better examination.

If an entire bank shows "bad", there is probably no RAM in that bank. This is easily verified. If one chip in a bank shows bad, it is also easy to see if that chip is missing.

If there is a chip in the socket marked "bad", first inspect the chip. Make certain it matches the memory size of the other chips in its bank. If it does, next check to see that all of its pins are firmly inserted into the socket. A chip may read "bad" if one of its legs is bent under the chip or if a pin is sticking outside the socket.

If none of the preceding are true, then the RAM identified as "bad" is probably defective. You may try swapping the chip with other RAM shown as good, reinsert the card, and rerun the test to confirm the first test results.

If the defective RAM was originally shipped with the card (see Chapter 2 for the shipping code on the card) or is RAM from a Checkmate Technology RAM Kit, then turn to Chapter 11 for warranty service information.

If the RAM is not from Checkmate Technology, check with the store that sold you the RAM regarding replacement. As discussed in Chapter 11, Checkmate Technology will replace other companies bad RAM for a service fee.

NON - RAM PROBLEMS

Failed components on the MultiRam //e Card are one source of problems if a program does not run properly or if 80-column video is not seen. Other trouble sources can exist.

One problem not related to the MultiRam //e Card but which can look like a RAM problem is an overloaded power supply.

If you are running a full Apple, every slot with a peripheral card in it, you are probably overloading your Apple's power supply. If a seemingly memory related problem occurs in this situation, try removing some of the cards from the Apple to see if the problem disappears.

To insure longer life for your computer, remove all cards that are only occasionally used. A modem, speech synthesizer, CP/M card, can draw up to 80% of its operating current even when it is not being used. If you need the use of all your cards in your Apple at one time there are other remedies. The enhanced //e kit from your Apple Dealer, includes a 65C02 that can reduce power consumption by 180 milliamps. Larger power supplies are available that double to the power rating of the standard power supply. Even if your computer is working fine, add a fan to give it a helping hand.

CHAPTER 6

HARDWARE & SOFTWARE COMPATIBILITY

MultiRam //e's operation can be enhanced by using other manufacturer's hardware and software products along with it. Some of the more useful products are described in this chapter.

HARDWARE

All hardware products tested with the MultiRam //e card have been compatible: modems, mouse, printer cards and printers, co-processor cards, hard drives, etc.

The three most useful hardware additions that could be made to increase MultiRam //e's usefulness are a large capacity disk drive, co-processor card, and a non-interruptible power supply.

Disk Drives

MultiRam //e's large on-board memory, especially if expanded to a full 1.5 megabytes, is far larger than the standard Apple II floppy disk drive's unformatted capacity of approximately 144K.

To better take advantage of software that can use MultiRam //e's large memory, you may want to consider purchasing larger capacity disk drives. Using larger capacity drives, you may more easily save and load large data files as well as keep many more programs on one disk.

Large capacity floppy disk drives are currently available for the Apple //e and others will soon be available. Larger floppy disk drive capacities range from 160K to over a megabyte and come in 8 inch, 5 1/4 inch, and 3 1/2 inch sizes.

Hard disk drives have greater storage space available and faster access times to information stored on them than floppy disk drives. Hard disk drives for the Apple range from 5 megabytes to over 50 megabytes. Most support all the major operating systems used on the Apple.

Whether used in a single-user setting or networked for multiple users, a hard disk drive makes a very effective companion to the MultiRam //e Card. As more ProDOS software like AppleWorks is made available for the Apple, a hard drive and MultiRam //e will make an even stronger combination as ProDOS is capable of creating 16 megabyte files, more than enough to handle large files that can be manipulated with MultiRam //e.

Hard drives available for the Apple should work well with MultiRam //e. A number of hard disk drives have been tested with the MultiRam //e Card. The Sider, an increasingly popular inexpensive hard disk drive manufactured by First Class Peripherals, and 5 to 42 megabyte hard drives with networking ability

manufactured by Space Coast Systems, Inc. have been satisfactorily tested with the MultiRam //e Card and the AppleWorks program modified for MultiRam //e use.

Before buying a large floppy drive or hard disk drive, check to see that all the operating systems you would like to use on your Apple (ProDOS, DOS 3.3, Pascal, and CP/M) work on the drive. Further, if you use copy protected commercial software, be certain that the drive will run the software you now use or check with the software publishers to see if they have a version that will run on the drive in question.

C o - P r o c e s s o r C a r d s

The speed of the Apple's motherboard 6502 or 65C02 processor is acceptable for use with 64K or 128K of memory. You may discover, however, if you work with large AppleWorks/MultiRam files that some operations, noticeably those dealing with large spreadsheet files, take a relatively long time.

Co-processor boards using faster 65C02 processors can be added to the Apple //e to speed up its operations. In testing, boards such as the Accelerator by Titan Industries, and The SpeedEMON by Micro Computer Technologies, speed up the operation of many AppleWorks functions threefold. A co-processor card used in conjunction with a hard disk drive and the MultiRam //e Card makes AppleWorks a superlative integrated program. Power consumption of these speed-up cards is high. See Chapter 3 for additional information about problems with power consumption.

Most CP/M cards may be used in conjunction with MultiRam //e with MultiRam //e's optional CP/M disk emulation software. Any disk intensive CP/M program, like Wordstar, shows increased speed from having a RAM quick, large disk drive to load and save files to. MultiRam //e and its optional CP/M disk emulator software should work with any CP/M card that works in slots 1 through 7 of the Apple.

Checkmate Technology is in the process of developing a fast 16 bit 65C816 processor card for use with the MultiRam // Card. The 65C816 processor is compatible with the Apple's 6502 processor so that the card will offer maximum capability as well as fast execution speed and direct (not bank switched) addressing of all MultiRam //e memory.

N o n - i n t e r r u p t a b l e P o w e r S u p p l i e s

In a business environment, a power failure that occurs while you are working with a large data file stored all in memory could be disastrous. At best, data must be re-entered costing lost time and aggravation. At worst, if a power failure occurs while information is being written to disk, a power surge or other disruption accompanying the power failure could cause damage to the file being saved so that the file is unusable.

A non-interruptable power supply offering quick response time to a loss of power as well as having sufficient power to operate the computer long enough to allow information stored in MultiRam //e's memory to be saved to hard or floppy drives would be ideal if you are using MultiRam //e in a business setting. Checkmate Technology plans to offer a non-interruptable power supply that meets these specifications to MultiRam //e owners in the near future.

S O F T W A R E

Checkmate Technology plans to offer for sale modifications to popular existing software (like the AppleWorks Memory Expansion disk) that can best take advantage of MultiRam //e's large memory.

Revised spreadsheet and data base software packages that will use MultiRam //e's large memory are also expected to be released by third party software publishers later this year.

Some programs currently on the market will use more than 64K of MultiRam //e's memory, though not all of the memory on a card may be recognized. FlashCalc, MagiCalc, and Magic Office are examples of programs which will recognize 64K banks 0, 3 and 5 of MultiRam //e memory if 256K RAMs are located in RAM Bank A.

Unprotected programs that return to a program or data disk frequently can benefit now from MultiRam //e RAM disk emulation software. Most popular, unprotected programs can run out of a RAM drive and use the same RAM drive to store their data, thus greatly speeding up these programs. These programs would boot-up almost instantaneously. When running them, their disk access time would be almost unnoticeable. RAM fast disk speed would also allow you to very quickly and easily switch between programs as needed.

Part 3

PROGRAMMING THE MULTIRAM //E CARD

Programming the MultiRam //e card explains how to program for 80-column video, how to use auxiliary memory, and how to manage multiple auxiliary bank addressing.

Chapter 7

80 - COLUMN DISPLAYS

This chapter explains how to switch to and from MultiRam //e's 80-column mode and how to control 80-column displays from both keyboard and program control.

These operations with the MultiRam //e Card work the same as the standard Apple 80-Column Text Card and other compatible cards. For those who are experienced in programming the 80-Column Text Card, you may wish to skip over this chapter.

It is not necessary that you understand the material in this chapter if you use your //e exclusively with applications software already written to utilize an 80-column card on the //e.

KEYBOARD CONTROL

MultiRam //e's 80-column display can be turned on and off from the keyboard. Escape editing commands for editing programs are available only from the keyboard.

Activating 80-Column Displays

From the keyboard, turn on the MultiRam //e Card's 80-column display by typing "PR#3 <Return>." The screen will clear and the cursor will appear in the upper left corner of the screen. The 80-column cursor is a narrow, solid, non-blinking block versus the large, blinking checkerboard cursor of the 40-column screen.

Most commercial programs that display 80-columns will turn on the 80-column display automatically. Also, if you are using the CP/M or Pascal operating systems, the card will be automatically activated by the operating system when you boot up the operating system disk.

Switching Between 40- and 80-Columns

To return to 40 columns after the 80-column card is activated type "Escape 4 <Return>" (press and release the Escape key, press and release "4", press and release the "Return" key). You will return to a 40-column screen. Do not switch to 40-columns when the cursor is beyond the 39th column because the first character output to the 40-column screen will write into active program memory causing a potential program crash. This is due to //e firmware and is not a function of the MultiRam Card.

Although the screen will return to a 40-column display, the 80-column firmware of the MultiRam //e Card remains active. The large, solid, non-blinking cursor you see in 40-columns versus the normal checkerboard cursor lets you know the card is still active.

To return to an 80-column display, press "Escape 8"

D e a c t i v a t i n g 8 0 - C o l u m n D i s p l a y s

When using programs that were written for the Apple II and II+, you may have to deactivate the MultiRam //e to prevent improper screen displays. Also, when sending output to a printer or other peripheral, the card should be deactivated to prevent screen displays from breaking up.

To deactivate the card, enter "Escape Control-Q." Do not do so when the cursor is beyond the 39th column because the first character output to the 40-column screen will write into active program memory potentially causing a program crash. As with the "Escape 4" command, "Escape Control-Q" is another limitation in the //e firmware.

When the MultiRam //e Card is deactivated, you will see the 40-column display reappear with its large, blinking checkerboard cursor at the bottom of the screen.

To go back into 80-column mode, you will have to type "PR#3", or re-boot a program that automatically switches into 80-column display.

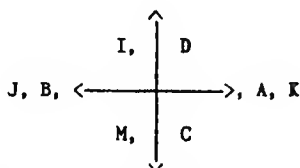
Pressing "Control-Reset" will also deactivate the MultiRam //e, but may also clear the program currently in your computer's memory.

E d i t i n g C o m m a n d s

Escape editing commands are available in both 40 and 80-column screens. You may move the cursor anywhere on screen when in edit mode to edit an Applesoft or machine code program.

To enter editing mode, press the Escape key and release it. When the card is active, entering the edit mode causes a "+" to appear inside the cursor.

Pressing the following characters after entering editing causes the cursor to move in the indicated direction:



You may type the letter keys in upper or lower case.

The A, B, C, and D keys will move the cursor once after the Escape key is pressed. The edit mode ends once these keys are pressed. The edit mode stays active after pressing the I, J, K, M and arrow keys and you may continue to move the cursor with these keys until you press a non-edit key.

U p p e r c a s e R e s t r i c t M o d e

To make lower case character entry easier when entering text within Applesoft PRINT statements, use the restrict mode on an unenhanced Apple //e. To enter restrict mode, press "Escape R."

With the "Caps Lock" key in the up position to allow lower case entry, all Applesoft commands typed from the keyboard will appear in upper case but characters typed after a quotation mark will appear in lower case. Use the "Shift" key to enter an upper case character within a PRINT statement.

Press "Escape T" to turn off this feature.

This "Restrict" mode is not available on an enhanced //e as Applesoft commands may be entered in lower case.

C o n t r o l C h a r a c t e r D i s p l a y

The enhanced //e allows printing of control characters to the screen or can suppress them.

Using "Escape Control-E" from keyboard or program control causes most control characters to be printed to the screen. Using "Escape Control-D" disables sending all control characters but carriage returns, line feeds, back spaces, and the bell. The 80-column firmware must be active for these commands to work.

These commands are not available on the unenhanced //e.

P R O G R A M C O N T R O L

Following are commands you may use from program control when working with the 80-column screen. These commands require that the 80-column card be active. From Applesoft use a PRINT CHR\$(N) statement. The term "N" represents a ASCII value.

C a r d A c t i v a t i o n / D e a c t i v a t i o n

Use a PRINT CHR\$(4);"PR#3" line to turn on the card when using Applesoft with DOS or ProDOS in memory. Using a PRINT "PR#3" will also work but with DOS or ProDOS in memory this will disconnect the operating system.

The following control commands will select 40 or 80-columns when the card is active or will turn off the card:

Control Character	Ascii Value	Action
CTRL Q	17	Set a 40-column display if the card is active
CTRL R	18	Set an 80-column display if the card is active
CTRL U	21	Deactivate the card returning to a 40-column display

C u r s o r M o v i n g

From within a program the cursor may be moved by using these commands:

Control Character	Ascii Value	Cursor Action
CTRL H	8	Moves one space to the left; at the left window edge, moves to the right end of the line above
CTRL J	10	Moves down one line; scrolls at window bottom
CTRL M	13	Moves to the left end of the window; scrolls at window bottom
CTRL V	22	Screen scrolls down; cursor stays in current position
CTRL W	23	Screen scrolls up; cursor stays in current position
CTRL Y	24	Moves to upper left corner of window
CTRL \	28	Moves one space to the right; at the right window edge, moves to the left end of the line below
CTRL ^	30	Moves to a designated location; within a Pascal program, the next two characters output, minus 32, moves the cursor to an x and y location.

VTAB commands work normally unless a window is set. If a window is set in 80-columns, VTAB one line above the desired line and then issue a PRINT command to bring you to the desired line.

Using a non-enhanced //e, do not use HTAB or POKE 36 commands in an 80-column program. Substitute a POKE 1403, (horizontal position 0 to 79) in place of these commands. Using an enhanced //e, HTAB, TAB, SPC and comma tabbing work as they do on the 40-column screen.

Pascal's cursor can be turned off to speed up screen displays by approximately 30 percent using an enhanced //s with Apple Pascal 1.2. Turn the cursor off with "Control-F"; turn the cursor on with "Control-E."

Screen Clearing

The screen may be completely or partially cleared with these commands:

Control Character	Ascii Value	Clearing Action
CTRL K	11	Clears from the cursor to the end of the window
CTRL L	12	Clears the window; moves the cursor to the upper left corner of the window
CTRL Z	26	Clears the line the cursor is on
CTRL]	29	Clears from the cursor to the end of the line

The HOME command will clear the 80-column display.

Display Features

Some display commands work differently when the card is active than they do in the normal 40-column display.

If an INVERSE command is active and the HOME command is given, the screen will clear to white and the characters will be black. With the normal 40-column display, the screen would clear to black and characters would appear inversed.

The FLASH command does not work when the card is active.

The following control commands can also affect the display from within a program:

Control Character	Ascii Value	Display Action
CTRL N	14	Sets a normal display
CTRL O	15	Sets an inverse display

Chapter 8

PROGRAMMING AUXILIARY MEMORY

This section reviews standard auxiliary memory programming techniques for the MultiRam //e Card. These techniques are the same as those used when programming the Apple Extended 80-column Text Card, and other compatible cards that plug into the auxiliary connector slot.

If you are familiar with programming an extended memory card you may wish to go directly to Chapter 9.

To access auxiliary memory from a program, to transfer program control or move data to auxiliary memory, or to employ double high resolution graphics, requires assembly or machine language programming skills.

MultiRam //e's additional memory, above the standard 64K auxiliary memory, requires switching from one bank of 64K auxiliary RAM to another, by means of soft switches. This is detailed in Chapter 9

GENERAL INFORMATION

The Apple uses a 6502 microprocessor to control its operation (65C02 in the //c and the Enhanced //e). This microprocessor can address only 64K of memory at one time. To use the auxiliary memory of the MultiRam //e Card, the //e uses a set of soft switches, contained in its Memory Management Unit, to control the address bus and switch between the 64K of the motherboard and the 64K auxiliary memory on the MultiRam //e. The soft switches are in turn controlled through software.

The 64K of Auxiliary memory on the MultiRam may be used for program or data storage, except for 1K which is used to control the 80-column display. If you are going to use only 40-column mode, you may use the full 64K.

The video display of the //e is controlled by routines located in specific areas of memory. In 40-column mode, Text Page 1 and Text Page 2 control text and lo-res graphics display in the main memory (see Table 8.1 for locations). For 80-column mode, Text Page 1 of both Main and Auxiliary memory control the display.

Double High-Resolution Graphics may be turned on via soft switches. This doubles the horizontal resolution of Graphics Page 1. To turn on the double hi-res graphics, write any value to soft switch 80COL (\$C00D), TEXT Off (\$C050), HIRES On (\$C057), and MIXED Off (\$C053). Remember that double hi-res graphics does not work in the early Rev. A version of the //e motherboard.

BANK SWITCHING

Because the 6502 or 65C02 can address only 64K of memory at one time, in order to utilize the auxiliary memory on the MultiRam, the computer must switch between the 64K RAM of the motherboard and the 64K of the MultiRam card. This is called "bank switching."

Soft switches are locations which control which of the banks of memory is being addressed at a given point. Each soft switch has two locations assigned to it. Write to the location that has the effect you desire with a STA, STX, STY instruction or a POKE command from Applesoft.

The soft switch called RAMRD selects either the main or auxiliary memory for READ operations. The soft switch RAMWRT selects either main or auxiliary memory for WRITE operations. Read and Write may be set independent of one another so that a program may read data from a location in one bank and write it to another location in the other bank. To access main memory, both RAMRD and RAMWRT must be Off; to access auxiliary memory, both must be On.

ALTZP selects locations in one bank or the other for both Read and Write operations in Page 0, the stack, and the language card.

The 80STORE switch controls the effects of some of the other switches, and it is particularly important to set it correctly. 80STORE must be OFF if RAMRD and RAMWRT are to control the entire memory from \$0200 to \$BFFF. With 80STORE On, the PAGE2 switch can select either main or auxiliary memory. If HIRES is turned Off, PAGE2 will select Text Page 1 from either main or auxiliary memory; if HIRES is On, PAGE2 selects Hi-res Graphics Page 1 and Text Page 1 from main or auxiliary memory. RAMRD and RAMWRT do not affect the Text Page while 80STORE is On. Table 8.2 shows the relationships of these three switches.

Table 8.2
Functions of soft switches 80STORE, PAGE2, and HIRES

80STORE:	OFF	ON
PAGE2 OFF	Use RAMRD, RAMWRT	Access MAIN Memory (RAMRD, RAMWRT no effect)
HIRES OFF	(no effect)	Text Page 1
HIRES ON	(no effect)	Hi-res Page 1
PAGE2 ON	Access Hi-Res Page 2	Access AUX. Memory (RAMRD, RAMWRT no effect)
HIRES OFF	(no effect)	Text Page 1
HIRES ON	(no effect)	Hi-res Page 1

In Table 8.1, the first address given for each soft switch is the location at which the status of the switch can be read. When this location is read in machine language, a 0 (zero) in the high (bit 7) indicates the switch is Off, a 1 shows the switch is On. If the location is read from BASIC, a value of 127 or less indicates the switch is Off, 128 or greater indicates On.

Table 8.1
Soft switches

Switch Name	Location		Function
	Hex	Decimal	
RAMRD	\$C013	49171	Read RAMRD switch
	\$C002	49154	OFF: Read Main 48K (\$0200-\$BFFF)
	\$C003	49155	ON: Read Aux. 48K
RAMWRT	\$C014	49172	Read RAMWRT switch
	\$C004	49156	OFF: Write to Main 48K
	\$C005	49157	ON: Write to Aux. 48K
ALTZP	\$C016	49174	Read ALTZP switch
	\$C008	49160	OFF: Use Main memory, Page 0, stack bank-switched (16K) memory
	\$C009	49161	ON: Use Aux. memory, Page 0, stack bank-switched memory
80STORE	\$C018	49176	Read 80STORE switch
	\$C000	49152	OFF: Enable RAMRD, RAMWRT switches for video pages
	\$C001	49153	ON: Override RAMRD, RAMWRT switches for video pages (use PAGE2 switch)
TEXT	\$C01A	49178	Read TEXT switch
	\$C050	49232	OFF: Display graphics
	\$C051	49233	ON: Display text
MIXED	\$C01B	49179	Read MIXED switch
	\$C052	49234	OFF: Full graphics
	\$C053	49235	ON: Mixed text and graphics
PAGE2	\$C01C	49180	Read PAGE2 switch
	\$C054	49236	OFF: 1. Display video page 1 using RAMRD, RAMWRT (80STORE off) 2. Display video page 1 using main memory (80STORE on)
	\$C055	49237	ON: 1. Display video page 2 using RAMRD, RAMWRT (80STORE off) 2. Display video page 1 using AUX. memory (80STORE on)
HIRES	\$C01D	49181	Read HIRES switch
	\$C056	49238	OFF: Low-res graphics selected
	\$C057	49239	ON: Hi-res graphics selected
80COL	\$C01F	49183	Read 80COL switch
	\$C00C	49164	OFF: Display 40-columns
	\$C00D	49165	ON: Display 80-columns

AUXMOVE AND XFER

Two built-in assembly language subroutines may be used to transfer data and program control between main memory and auxiliary memory on the MultiRam //e Card. These are AUXMOVE (starting location \$C311) and XFER (\$C314).

AUXMOVE is used to move blocks of data between main and auxiliary memory. Three pairs of bytes are used to pass addresses to AUXMOVE. A1 is used for the starting address of the source block (A1L at \$3C for low-order byte; A1H at \$3D for high byte); A2 for source ending address (A2L at \$3E for low byte; A2H at \$3F for high byte); and A4 for the destination starting address (A4L at \$42 for low byte; A4H at \$43 for high byte).

Data addresses must be put into byte pairs in Page 0, and the carry bit set to select move from Main to Auxiliary (SEC) or Auxiliary to Main memory (CLC). This must be done before calling the AUXMOVE routine. AUXMOVE cannot be used to copy data in the memory space switched by ALTZP (Page 0, stack, bank-switched memory).

When AUXMOVE is called, the block of data specified by the A registers is copied in the direction specified by the carry bit. When complete, the x and y registers and accumulator are back as they were when the subroutine was called.

XFER is used to transfer program control between main and auxiliary memory. To use the subroutine XFER to transfer control to and from segments in auxiliary memory, you must first set up three parameters: 1) the address of the routine being transferred to; 2) the direction—Main to Auxiliary memory, or vice versa; and 3) which Page 0 and stack to use.

The low byte of the program starting address is placed at \$3ED, the high byte at \$3EE (low byte first). The carry bit is set (SEC) to transfer from main to auxiliary, or cleared (CLC) to go from auxiliary to main memory. Set the overflow bit to use Page 0 and stack in auxiliary memory, or clear (CLV) the overflow bit to use Page 0 and stack in main memory.

Be sure to save the current stack pointer in current memory space before using XFER and restore it afterwards.

Control is passed to the XFER routine by a jump instruction rather than a subroutine call. The accumulator and transfer address are saved on the current stack, the soft switches set for the parameters selected, and the jump to the new program is executed.

Chapter 9

AUXILIARY MEMORY MANAGEMENT

The MultiRam //e Card can contain 768K of memory. The Apple //e's 6502 processor can use this memory as 12 banks of ordinary 64K auxiliary memory. With a full 1.5 megabyte of memory installed using an expansion board, 24 banks of 64K auxiliary memory are possible. How to use these different memory banks from within control by machine language routines is the subject of this chapter.

This chapter should be read by programmers who intend to write assembly language programs using the MultiRam //e Card's memory or assembly language subroutines that can be called by higher level languages.

SELECTING AUXILIARY MEMORY BANKS

Because the Apple's 6502 processor is an 8 bit processor, it can directly address only 64K of memory. The Apple addresses the 64K memory in a standard auxiliary bank by "bank switching" using software controlled switches. These soft switches cause different memory areas to be switched into the address range the Apple can read and write to and are discussed in Chapter 8.

Each of MultiRam //e's 24 possible 64K memory banks can be moved into the address area reserved for normal auxiliary memory by writing the number of the desired 64K auxiliary bank into a soft switch located at \$C07X. Any hexadecimal number \$0 to \$F entered in the place of the "X" will cause the bank number selected to be switched into addressable memory. The Apple then can use this memory bank as it normally would use auxiliary memory. See "Softswitch Selection" in the following section for more information on use of the soft switch.

MultiRam //e's 24 auxiliary banks (12 on MultiRam //e, 12 on the optional MultiRam RGB memory expansion card) are associated with fixed RAM Bank locations on the card. As Table 9.1 shows, Banks A, B, and C have four 64K auxiliary memory banks associated with each of them. Four auxiliary banks can be associated with each RAM Bank as a set of 256K RAM chips can be placed into a RAM Bank and a set of 256K RAM chips is the equivalent of four 64K banks.

Table 9.1 Auxiliary Memory Bank Location (Hex notation)

MultiRam //e RAM Bank	MultiRam //e 64K Aux. Bank Number	MultiRam RGB 64K Aux. Bank Number
A	0, 3, 4, 5	10, 13, 14, 15
B	1, 6, 7, 8	11, 16, 17, 18
C	2, 9, A, B	12, 19, 1A, 1B

Values \$C to \$F written to \$C07X select Aux. Bank \$0; values \$1C to \$1F select Aux. Bank \$10.

Auxiliary bank \$0 is the most important of the banks as it contains video display memory. The Apple //e's 80-column video text page (\$400-\$7FF) and double hi-res graphics page (\$2000-\$3FFF) are complete and useable only when auxiliary bank \$0 is selected.

The LEDs on the front of the MultiRam //e Card show which bank is currently active. If more than one light is on, add together the numbers to the left of the lit lights to see which bank is active. The LEDs are numbered 1, 2, 4, and 8 from top to bottom. For example, from the monitor, if you enter "C078:1<cr>", you will see the top LED lighted indicating 64K auxiliary bank 1 is selected. The LED will stay on until another value is entered into \$C078 or the card is reinitialized with a cold boot.

PROGRAMMING GUIDELINES

The following programming guides will help you in writing your own software to effectively use the card's memory. These guides are not comprehensive but should cover the most common questions you may have regarding card programming.

Soft switch Selection

As previously explained, writing a value associated with a MultiRam //e 64K auxiliary memory bank to any of the \$C070 to \$C07F memory locations in the //e causes that 64K memory bank to be selected as the auxiliary bank.

Writing anything to the \$C07X locations also causes the Apple's game paddle timers to be activated. If you are writing a program using a joystick, game paddle or other device attached to the game controller port, you should read the \$C07X address with a LDA, LDX, LDY instruction if you only intend to trigger the timer for the joystick. If you write to the \$C07X register with a STA, STX, or STY instruction, you may switch to an undesired auxiliary bank. Also, remember that the paddle timer must time out before you can use the \$C07x address again. Allow 3 to 4 milliseconds to elapse before you use \$C07X again.

If you are developing software to run with both the MultiRam //e Card and Checkmate Technology's MultiRam C Card (adding 256K or 512K to the Apple //c) you should not write to \$C070, \$C077, \$C07E, and \$C07F as these switches perform video related operations on the //c. All programming techniques discussed in this chapter also apply to the MultiRam C memory card.

Initializing The Card

When the Apple is first turned on, auxiliary bank 0 (zero) is selected. MultiRam //e is therefore initially configured the same as a standard extended memory card.

A program should not assume bank 0 (zero) will be immediately available to it. A program may have been run previously that left another bank selected. Make it a practice to select bank 0 (zero) when first addressing the card and when exiting your program. This will ensure error free operation for your program and programs run after it.

Identifying MultiRam //e Memory

After selecting auxiliary bank 0 (zero), your program should next determine how much memory is available on the card for use by your program.

Memory banks can be identified by writing a particular bit pattern into a specific location in the memory bank. Next read the memory location that the pattern was written into and compare what is found against the original pattern. A 64K auxiliary memory bank exists if there is a match.

Many different techniques can be used to perform the write/read/compare operation. A preferred method is to use a descending loop that selects the highest memory bank available on the card (\$1B for a full 1.5 megabyte combination if the MultiRam RGB expansion card is connected to MultiRam //e) writes the expected auxiliary bank number and a checksum value into two bytes of that bank, decrements the bank counter and then repeats the process ending with bank 0 (zero). This would be followed by a descending loop that reads the bytes from the two bytes of each bank and compares them against the expected value.

A descending identification loop is preferable as it consistently identifies usable 64K banks from the lowest possible bank number to the highest.

For example, a RAM Bank populated with 64K chips can be successfully addressed by writing to any of the four bank numbers associated with that RAM Bank. Table 9.1 shows banks 1, 6, 7, and 8 are in Bank B. If RAM Bank B has a set of 64K chips installed and an ascending identification loop is used, an 8 would be the last number written to the bank. The 1, 6, and 7 successfully written earlier would be overwritten by the 8. The bank would therefore be incorrectly identified as bank 8 by the read loop.

Further complicating the use of an ascending loop, MultiRam //e decodes the values \$0C, \$0D, \$0E, and \$0F written into the \$C07X strobe as a bank 0 (zero) memory location. Therefore, an ascending loop on Bank A with only 64K RAM present would determine that a bank \$0F was present. The same decoding is done for the expansion card when connected and values \$1C, \$1D, \$1E, and \$1F decode to bank \$10.

An example of a routine to identify useable memory is as follows:

	LDX BANK#	Bank number to start, \$1B best
MARKALL	STX BNKSELECT	Select bank with the \$C07X bank selected
	STX ALTZP	Write to \$C009 for aux. zero page
	STX TEST1	Write the bank number to first location in zero page of selected bank
	TXA	Prepare for EOR
	EOR #FF	Reverse the bank's bits setting
	STA TEST2	Write the checksum byte to second location in zero page of selected bank
	DEX	Decrease the bank counter
	BPL MARKALL	Loop through to bank zero
	LDX BANK#	Bank number to start, same as MARKALL start
READALL	STX BNKSELECT	Select bank with the \$C07X bank selected
	CPX TEST1	Compare bank number against memory
	BNE MAPFAIL	Memory map marked showing bank n with no memory
	TXA	Prepare for EOR
	EOR #FF	Prepare the checksum for the double check
	CMP TEST2	Compare the EOR'd byte for the double check
	BNE MAPFAIL	Memory map marked showing bank n with no memory
	BEQ MAPPASS	Memory bank exists, mark bank n into memory
READNEXT		MAPFAIL, MAPPASS return here
	DEX	Decrease the bank count
	BPL READALL	Loop through to bank 0
	STX MAINZP	Select main memory zero page
	RTS	

Memory Bank Mapping

You should keep a record of available memory for your program's use after you have identified the memory on the card. Either a byte map or a bit map could be used for the memory map. You may wish to construct a map that not only shows which 64K banks are useable, but like DOS and ProDOS sector bit maps, also keeps track of availability of smaller increments of memory. The auxiliary bank memory map could then become part of a larger memory manager.

You will also need to use a byte or bytes to track the memory bank in current use. The \$C07X strobe cannot be read to see which bank was last called.

Memory Transfers

Data can be transferred from main memory to auxiliary memory and back using standard //e extended memory card transfer commands. The RAMRD and RAMWRT soft switches and the AUXMOVE routine described in Chapter 8 all function normally. The only difference is the additional need to determine which of the MultiRam //e's 64K banks should be used for the transfer.

Data can also be transferred from one MultiRam //e 64K auxiliary bank to another 64K auxiliary bank. This could be done by selecting the source bank, copying the source bank's data into main memory using AUXMOVE or your own memory move routine, selecting the 64K destination bank, and then writing the data to the destination bank from main memory.

Another method is to transfer data directly from one bank to another, one byte at a time, through the accumulator. The memory move routine doing the transfer must always be located in the part of memory not being transferred. The safest method of doing this type of transfer is to locate the move routine on the motherboard main or bankswitched memory address.

80 - Column Addressing

The 80-column display is derived from 64K bank 0 only. When another bank is active, the 80-column display will still come from bank 0; the RAM in bank 0 is automatically refreshed during the //e's video refresh cycle. Therefore, you do not have to keep a mirror image of the bank 0 text page area in other banks in order to maintain the 80-column display.

To read and write to the 80-column screen, auxiliary bank 0 (zero) should be selected. If you write to the text video page area with some other bank selected while an 80-column display is active, information displayed will become garbled. You may only safely write to the text page area of an auxiliary bank other than bank 0 if an 80-column display is not active.

To avoid potential problems, you may want to exclude the 80-column text page area (\$400-\$7FF) from use on all banks.

Similar warnings apply to double hi-res displays.

Reset Key Trapping

Pressing the Reset key will not automatically switch in auxiliary bank 0 (zero). If you would like to direct your program to a specific auxiliary bank location when the Reset key is pressed, you must change the reset vectors \$3F2 and \$3F3 to point to a routine that will write the desired bank number into \$C07X.

Interrupt Handling

Interrupts are handled in the Apple //e by an interrupt vector located at \$FFFE. The \$FFFE location is normally ROM address.

If an auxiliary bank's bank-switched memory is active when the interrupt occurs, that bank must have a vector at the \$FFFE location in its memory pointing to an interrupt handler routine on motherboard main memory. The interrupt handler routine should be able to return to the bank that was active when the interrupt occurred if a "bank active" temporary byte is being maintained by your program in main motherboard memory (\$200-\$BFFF) or a defined location in another area.

An alternative method to handling interrupts is to disable interrupts with a SEI instruction whenever auxiliary bank-switched memory is in use. When switching out of auxiliary bank-switched memory, interrupt requests could then be enabled with a CLI command.

Part 4

MULTIRAM //E SERVICE GUIDE

The MultiRam Service Guide describes the
MultiRam //e warranty and explains
Checkmate Technology's service policies.

Chapter 10

THE WARRANTY

The MultiRam //e Card, like all of Checkmate Technology's peripheral cards, carries a 5 YEAR LIMITED WARRANTY.

CHECKMATE TECHNOLOGY, INC. warrants products against defects in material and workmanship for a period of 5 years (90 days for software) after purchase. During the warranty period, CHECKMATE TECHNOLOGY, INC. will at its option, repair or replace at no charge, or refund the purchase price to the purchaser, products that prove to be defective provided that the CHECKMATE TECHNOLOGY product is returned, shipping prepaid, to CHECKMATE TECHNOLOGY, INC. For products returned by other than U.P.S., the sender assumes greater risk of loss and delays.

Your sales receipt is your warranty validation. The receipt must be provided when requesting warranty work to be performed unless a valid product registration card is on file at the company headquarters. This warranty does not apply if, in the sole opinion of CHECKMATE TECHNOLOGY, INC., the product has been damaged due to abuse, misuse, misapplication, accident or as a result of service or modification by other than an authorized CHECKMATE TECHNOLOGY, INC. service center.

THIS WARRANTY IS EXPRESSLY IN LIEU OF ANY AND ALL WARRANTIES EXPRESSED OR IMPLIED. CHECKMATE TECHNOLOGY DOES NOT WARRANT THAT GOODS ARE MERCHANTABLE OR FIT FOR ANY PARTICULAR PURPOSE. CHECKMATE TECHNOLOGY SHALL NOT BE HELD RESPONSIBLE FOR ANY CONSEQUENTIAL DAMAGES OR LOSSES ARISING FROM THE USE OF THIS PRODUCT.

This warranty applies to CHECKMATE TECHNOLOGY products purchased in the United States. The warranty may vary for products purchased outside the continental United States. Contact CHECKMATE TECHNOLOGY, INC. for warranty service information.

SECOND HAND OWNERSHIP

Purchasers of used Checkmate Technology products should register the transfer with us. The cost of registration is \$10.00 and is a wise investment: any remaining unexpired warranty period will be transferred into your name and you will receive newsletters providing product information, including news of product updates.

To transfer the unexpired warranty period, the original owner must have filled out and returned the Registration/Warranty card to the company at the time of purchase.

If the original owner failed to register the card, for a one-time fee of \$30.00 we will transfer the unexpired warranty period (based on either the original purchase receipt showing date of purchase or by data of manufacture indicated by serial number on the card). Checkmate Technology reserves the right to decline any warranty transfer.

In order to transfer registration you must provide us with:

1. Product name.
2. Serial number on the card.
3. Name of previous owner (seller's name).
4. Your name, address, and telephone number.
5. Date of sale.
6. Your check for \$10 (\$30 if the card was not registered)

EXTENDING THE WARRANTY

If you would like to extend the warranty on your newly purchased or used card, we offer an EXTENDED WARRANTY PROGRAM.

New owners can take advantage of an additional five year warranty by sending a check for \$25.00 together with the Product Registration/Warranty Card. This offer is limited to new owners and must be sent to the company within thirty days of purchase.

Second hand owners can extend the unexpired warranty to a maximum of five years. The cost of extending the warranty is \$15.00 per year in addition to the transfer registration fee. For example, if there is only one year left on the unexpired warranty, a check for \$70.00 would be sent: \$60.00 for 4 years plus a \$10 registration fee (\$30 if the original owner did not register the card). Checkmate Technology, Inc. reserves the right to limit the duration it accepts for extended warranties.

Chapter 11

SERVICE POLICY

This chapter explains Checkmate Technology's repair and product update policies and other pertinent customer information.

HOW TO GET HELP

If you are unable to get your MultiRam //e Card to work properly after following the procedures in Chapter 3, please contact Customer Service; we will try to solve your problem as quickly as possible.

Telephone Help

Before sending in your MultiRam //e Card, you may want to call a Customer Service representative. Some problems may be solved without returning your card.

The telephone number and hours for technical assistance are:

Customer Service: (602) 966-5802

Hours: Mon. to Fri., 9am to 5pm (Mountain Standard Time)

If you need to call us, please have the following information available to save time:

1. Approximate date you mailed in your registration card.
2. Type of Apple //e in which the MultiRam //e is being used.
3. Other cards in the computer when using MultiRam //e.
4. Nature of the problem with the card.

If your card needs to be returned to the factory for repair, you will be issued a Return Merchandise Authorization number during your call. Write this number on the outside of the package that you will use to ship your card.

Telephone Policy

We want to be as helpful as possible with your questions and problems. We understand that the problem you are having is important, and we will provide technical assistance to try to answer it. We ask that you use our Customer Service telephone number for assistance. Support is not available through the toll-free order desk telephone number; collect calls are not accepted by Customer Service.

HOW TO RETURN A CARD

If it is necessary to return your MultiRam //e Card, follow these steps:

1. Please wrap your card in anti-static material. If none is available, wrap the card in aluminum foil. Returning a card without wrapping it in protective anti-static material or aluminum foil may cause further damage to the card and will VOID YOUR WARRANTY.
2. Include a note with your name, address, home telephone number, a daytime telephone number, plus:
 - A. Detailed description of the problem.
 - B. Type of //E motherboard used with the MultiRam //e Card, including any up-upgrades such as an enhancement kit installed.
 - C. Other cards in the computer when the problem occurred.
3. If you are a registered owner, meaning that you completed and returned your warranty registration card to the company, you are not required to send in proof of purchase. If you have not registered your MultiRam //e Card, include proof of purchase.

NOTE: ANY CARD RETURNED WITHOUT PROOF OF PURCHASE, OR WHICH IS NOT REGISTERED, WILL BE TREATED AS A PRODUCT OUT OF WARRANTY AND WILL BE CHARGED FOR NON-WARRANTY REPAIR AT RATES THEN IN EFFECT.

4. Pack the wrapped card, note, and proof of purchase (if needed) in a sturdy box and cushion the card with non-static packing material such as crumpled newspapers.
5. Ship the card, postage pre-paid, to:

Checkmate Technology, Inc.
511 South Rockford Drive
Tempe, Az. 85281-3021

Attn: Repair Dept.

Checkmate Technology, Inc. assumes no responsibility for cards either damaged or lost in shipping to Checkmate Technology for service. Please insure your valuable card. The cost of shipping insurance is low compared to replacing a lost card. We suggest U.P.S. as they insure the first \$100.00 at no charge and require the addressee to sign for each package.

RETURNING YOUR REPAIRED CARD

After repair or replacement, your MultiRam //e Card will be shipped to you in the U.S.A. by U.P.S., regular delivery, postage paid. Returns outside the U.S.A. may require a handling and shipping charge. Contact us regarding repairs outside the U.S.A.

RAM INSTALLATION & REPLACEMENT POLICY

You may return your card to Checkmate Technology if you would prefer to have the factory install added RAM on your card. Installed RAM will be tested at the factory on your card before return to you.

The cost of factory installed RAM is \$65.00 for a set of eight 64K DRAM and \$120.00 for a set of eight 256K DRAM. Checkmate Technology will return your card postage prepaid. These prices are subject to change. Contact the Customer Service department for current pricing.

Checkmate Technology warrants only that RAM on the MultiRam //e Card that was installed at the factory or RAM from a Checkmate Technology RAM Kit that was installed later. Such RAM is replaced at no charge if a defect in the RAM occurs during the 5 year warranty period.

Cards returned to the factory with defective RAM that was not supplied by Checkmate Technology, will be charged a \$25.00 service fee in addition to an \$8.00 charge for replacement of each defective 64K RAM chip and a \$15.00 charge for replacement of each defective 256K RAM chip. The repaired board is returned to you C.O.D.; you pay repair charges upon receipt of your board. Return shipping charges are included in the service fee. Fees are subject to change. Contact the Customer Service department for current pricing.

REPLACING DAMAGED DISKETTES

All Checkmate Technology disks are warranted for 90 days and will be replaced free of charge if a defect is discovered within the warranty period.

If you damage or wear-out a CHECKMATE TECHNOLOGY, INC. program disk after the 90 day warranty period and are a REGISTERED OWNER, we will replace your old program diskette for \$15.00, return postage prepaid. Non-registered software owners will be required to pay \$25.00. The additional ten dollars covers the costs of setting up a new owner registration.

Return the damaged or worn-out program diskette to the Customer Service Department, along with a note detailing the problem, and a replacement disk will be sent to you.

SOFTWARE UPDATES

Checkmate Technology may from time to time upgrade the standard features of the MultiRam Utility disk and other related MultiRam software. Registered owners will be notified of updates through our newsletter or special mailings.

Send \$5.00 to cover disk, shipping and handling costs, and an updated disk will be sent to you. You will not need to return the older software version.

NEWSLETTERS

Checkmate Technology will publish informative newsletters for registered owners of its products. Check-It-Out Newsletters will contain information on updates to products, information on modifications to software, general information on product usage, and news of product developments at Checkmate Technology, Inc.

If you would like to share any discoveries, programming tips, comments, or suggestions with other owners, please write to us and we will include them in the newsletter.

INDEPENDENT SOFTWARE DEVELOPERS

We actively solicit your help in making as many programs MultiRam //e compatible as possible. Owners submitting the most useful program modifications will receive, at Checkmate's discretion, products or cash rewards for their efforts.

In the newsletter we will also list the names of users of the MultiRam //e Card that have joined our "staff" by submitting original software that we can offer for sale. Anyone writing an original software package featuring the MultiRam //e Card is invited to call us to arrange a product review. Please do not send your original software without first contacting us. Call our Customer Service Department for further details.

SUGGESTIONS

If you have suggestions, comments, or questions regarding Checkmate's products, please contact us. Address correspondence to:

CHECKMATE TECHNOLOGY, INC.
509 South Rockford Drive
Tempe, Arizona 85281-3021

Attn: Andrew P. Niemiec President

Our goal is a satisfied customer.

WARRANTY REGISTRATION # 706639

Individual or Company Name _____

Person to Contact (if company owned) _____

Address _____

City _____ State _____ Zip _____

Work Phone (____) _____ Home Phone (____) _____

Purchased From _____

City _____ State _____ Date Purchased ____ / ____ / ____

Memory on the card when purchased? ____ K Maximum memory desired? ____ K

Which version of MultiRam software did you receive? _____

How did you find out about MultiRam? ☐ Dealer ☐ Another MultiRam owner

☒ Advertisement (where?) _____ ☐ Other (please specify) _____

Please rate the following:

Excellent Good Fair Poor

Your Dealer

MultiRam card

MultiRam software

MultiRam instructions

What do you like most about MultiRam? _____

What do you like least about MultiRam? _____

Why did you purchase MultiRam rather than another brand of memory card? _____

Besides AppleWorks, which programs would you most like to be able to use more of MultiRam's memory? _____

If you own or intend to buy an RGB monitor, which brand? _____

Do you belong to an Apple user group? 'Y' 'N' Group Name _____

Comments & Suggestions _____

TAPE HERE



Checkmate Technology, Inc.

Thank you for purchasing a
CHECKMATE TECHNOLOGY product.

To validate your warranty, maintain customer support,
and provide up-dates to your card, please fill out and
mail this warranty card to CHECKMATE TECHNOLOGY, INC.

FOLD & SEAL

Place
Postage
Stamp
Here

CHECKMATE TECHNOLOGY, INC.

509 South Rockford Drive
Tempe, AZ 85281-3021
USA

TAPE HERE

MultiRam™ Software Manual Addendum for Revision 5.0

The MultiRam Software Manual was written to support version 4.4.
This addendum has been prepared to update the manual for use with
version 5.0 and the MultiRam CX Plus.

Page 13	5th and 6th paragraph	The MultiRam version 5.0 supports AppleWorks versions 1.2, 1.3 and 2.0. Version 2.0 upgrade cost is \$ 50.00 and is available from your Apple dealer.
Page 15	Step 2	Replace the second sentence with: "Select either "1" or "2" depending on which version of AppleWorks you are using."
Page 24	Table 3.1	Add following entries to the 2 columns at the right: under 'MultiRam CX' - 1024K* under 'Desktop Size' - 805K* * for MultiRam CX Plus
Page 58 thru 60		<p>When using the MultiRam version 5.0 disk, disregard all of the information on these pages relating to file saving (loading files on page 60 remains valid). The file saving routine has been modified to prompt you at each stage and seeks your permission prior to deleting any old file. The saving routine now works by these rules:</p> <ol style="list-style-type: none"> 1. If the file you're saving IS NOT replacing an original file and there is not enough room on the disk, you will be taken to the segmentation process (just as if it were a large file). 2. If the file you're saving IS replacing an original and there is not enough room on the disk for both files (old and new), you will be asked "is it OK to delete the old file?". <p style="padding-left: 40px;">If you say NO, the saving of the new file will be cancelled. The new file will still remain in memory and the original file on the disk will be untouched.</p> <p style="padding-left: 40px;">If you say YES, the original file will be deleted to make space and the new file will be saved as one unsegmented file, provided there is enough room for it. If the space released by deleting the old file is not enough, you will be taken to the segmentation process.</p>

Page 109	Table 6.2	<div>1. In the second column, insert "768K"⁴ just after "832K in the first column.</div> <div>2. In the same column (2), insert "1024K"⁴ so that it is between "960K" and "1728K" in the third column.</div> <div>(The following is excerpted from Table 6.2. The underlined characters are the ones that are being added for the MultiRam CX Plus card).</div> <table><tr><th>MultiRam RGB & Ile</th><th>MultiRam CX & Plus</th><th>MRAM size</th><th>Total blocks</th><th>Blocks free</th><th>Blocks used⁶</th></tr><tr><td>:</td><td>:</td><td>:</td><td>:</td><td>:</td><td>:</td></tr><tr><td>:</td><td>:</td><td>:</td><td>:</td><td>:</td><td>:</td></tr><tr><td>768K</td><td>:</td><td>704K</td><td>1408</td><td>1370</td><td>38</td></tr><tr><td>832K¹</td><td><u>768K</u>⁴</td><td>768K</td><td>1536</td><td>1495</td><td>41</td></tr><tr><td>1024K¹</td><td>:</td><td>960K</td><td>1920</td><td>1870</td><td>50</td></tr><tr><td>:</td><td><u>1024K</u>⁴</td><td><u>1024K</u></td><td><u>2048</u></td><td><u>1995</u></td><td><u>53</u></td></tr><tr><td>1792K²</td><td>:</td><td>1728K</td><td>3456</td><td>3370</td><td>86</td></tr><tr><td>4096K³</td><td>:</td><td>4032K</td><td>8064</td><td>7870</td><td>194</td></tr></table>	MultiRam RGB & Ile	MultiRam CX & Plus	MRAM size	Total blocks	Blocks free	Blocks used ⁶	:	:	:	:	:	:	:	:	:	:	:	:	768K	:	704K	1408	1370	38	832K ¹	<u>768K</u> ⁴	768K	1536	1495	41	1024K ¹	:	960K	1920	1870	50	:	<u>1024K</u> ⁴	<u>1024K</u>	<u>2048</u>	<u>1995</u>	<u>53</u>	1792K ²	:	1728K	3456	3370	86	4096K ³	:	4032K	8064	7870	194
MultiRam RGB & Ile	MultiRam CX & Plus	MRAM size	Total blocks	Blocks free	Blocks used ⁶																																																			
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1792K ²	:	1728K	3456	3370	86																																																			
4096K ³	:	4032K	8064	7870	194																																																			
Page 143	Option 1 First sentence	Delete first sentence and substitute: "To copy all files from drive 1 using the slot the program was loaded from, press "1".																																																						
	Option 3 to 7	Change "slot 6" to "current slot" (i.e. the slot used when the program was executed).																																																						
Page 162	Table 7.2	Add an entry under "Maximum number of drives" : "MultiRam CX Plus - 1024K 3"																																																						
Page 163	Table 7.4	Create an entry under MultiRam CX Plus showing a size of 1024K with: 384K for drive 1, 384K for drive 2 and, 320K for drive 3																																																						

TEN DOLLARS

CHECKMATE USER-FRIENDLY REBATE COUPON

Get a \$10.00 rebate on ANY MultiRam extended memory card for your Apple IIe or IIc

Make your best deal with your **Checkmate** dealer, then receive an additional \$10.00 rebate directly from **Checkmate Technology**! Begin by completing your blue warranty card; this warranty card is **REQUIRED** to process your rebate. Send the completed card along with the **original** copy of your purchase receipt to **Checkmate Technology** (if you request, we will return your receipt). Be sure to include your name, address and phone number. To be eligible, your receipt must be dated between October 15, 1986 and December 31, 1986; all rebate requests must be received by January 31, 1987. Only one rebate request will be honored for each card you purchase. A brief description of MultiRam cards is listed on the back of this coupon.

Checkmate
Technology
TM



509 S Rockford Dr. • Tempe, AZ 85281
(602) 966-5802 • (800) 325-7347
MCI Telex: 6502788652

In Canada Contact EDP Marketing (403) 482-3014

This offer is void where taxed or prohibited. This rebate coupon has no cash value.
This coupon may be reproduced, but no more than one rebate request will be honored per eligible board.

MULTIRAM PRODUCTS BY CHECKMATE TECHNOLOGY

MultiRam RGB - 1 megabyte capacity memory card for the Apple //e that is expandable to 18 megabytes. Features include built-in RGB video (cable not included) and built-in interface for optional SRAM device which allows data exchange between Apple and IBM computers. The MultiRam RGB is designed to accept the MultiRam //EX, which converts the Apple //e into a true 16-bit computer.

MultiRam //e - 3/4 megabyte capacity memory board for the Apple //e. Can mate with the MultiRam RGB to provide 1 3/4 megabytes of memory power. Compatible with the //EX board for 16-bit capability. Full support of Apple graphics and 80-column modes. An excellent value.

MultiRam //EX - the original and the best no-slot "mini board" that uses the 65C816 microprocessor to turn your computer into a true 16-bit computer. Requires either the MultiRam //e or MultiRam RGB card.

MultiRam CX & 16-bit Option - 1/2 megabyte capacity memory board for the Apple //c. Features simple installation with no soldering or jumper wires. With the addition of the CX Kit, the //c may also be upgraded to a true 16-bit computer.

MultiRam CX Plus - this is a "piggyback board for the MultiRam CX allows an additional 512 RAM to be added, for a total of 1 megabyte on your Apple //c.

All MultiRam memory boards are fully compatible with International Apples and include **Checkmate's** exclusive software package that expands AppleWorks, provided super-fast Ram disks, and many other utilities that test memory and copy files. For further information please call on our TOLL-FREE number, 1-800-325-7347.

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